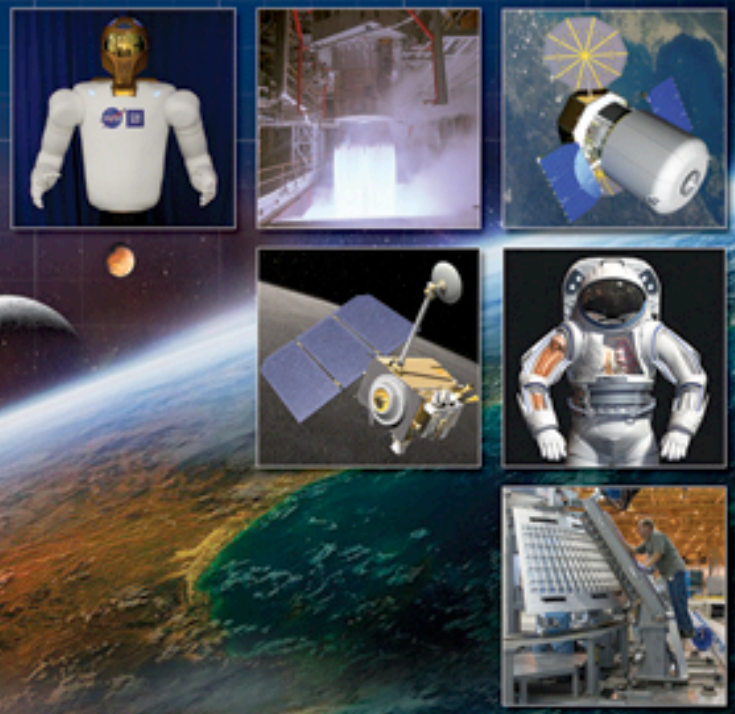
National Aeronautics and Space Administration

A 21st Century Space Exploration Enterprise

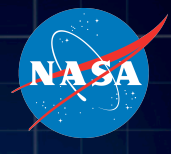


Dr. Robert Braun
NASA Chief Technologist
May 27, 2010

Themes of the President's FY11 NASA Budget Request

- **Top-line increase of $6B over 5 years** -- National investment in NASA is $100B over 5 yrs
- **Increase for Science ($2.5B over 5 years)** -- Largely focused in Earth science
- **Reverse past decline and provide modest increase for Aeronautics (~15% or $75M/yr)**
- **Shift in approach for Human Exploration program. The goal remains the same.**
  - Additional $600M to complete 5 remaining Shuttle flights (3 as of today)
  - Extension of ISS to at least 2020
  - Commercial approach to LEO access ($6B over 5 years)
  - Modernization of the KSC launch complex ($2B over 5 years)
  - Flexible Path strategy to extend human presence beyond LEO
  - Restructure of Constellation Program; Modified Orion development continues
- **Significant focus on Technology Development to reposition NASA on the cutting-edge**
  - Central principle of new Human Exploration strategy
  - New DARPA-like Space Technology Program ($5B over 5 years)
- **Increased emphasis on partnerships and STEM education**
  - Other government agencies, academia, industry and international

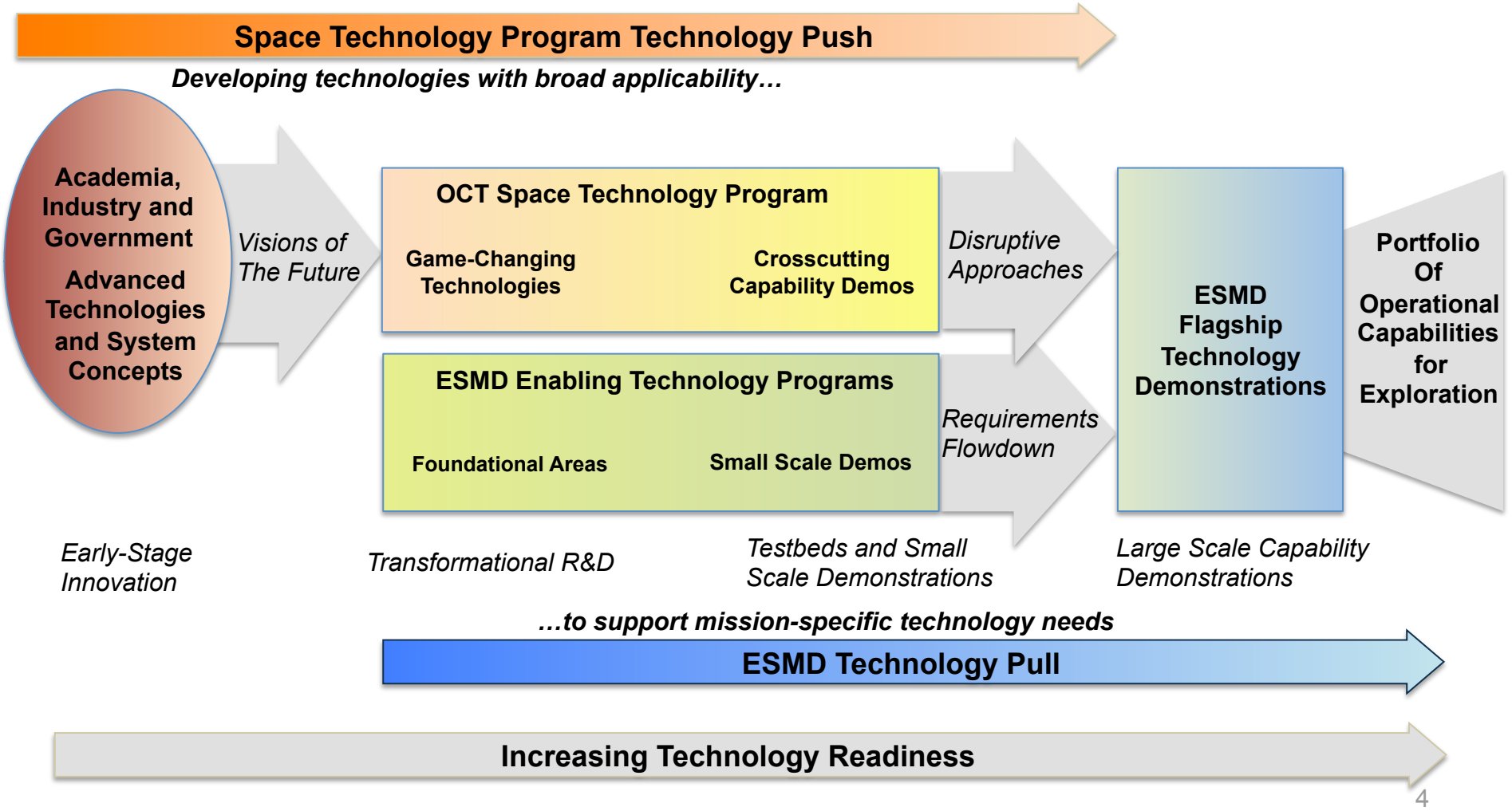
External Input Has Driven Development of NASA's Technology-Enabled Approach



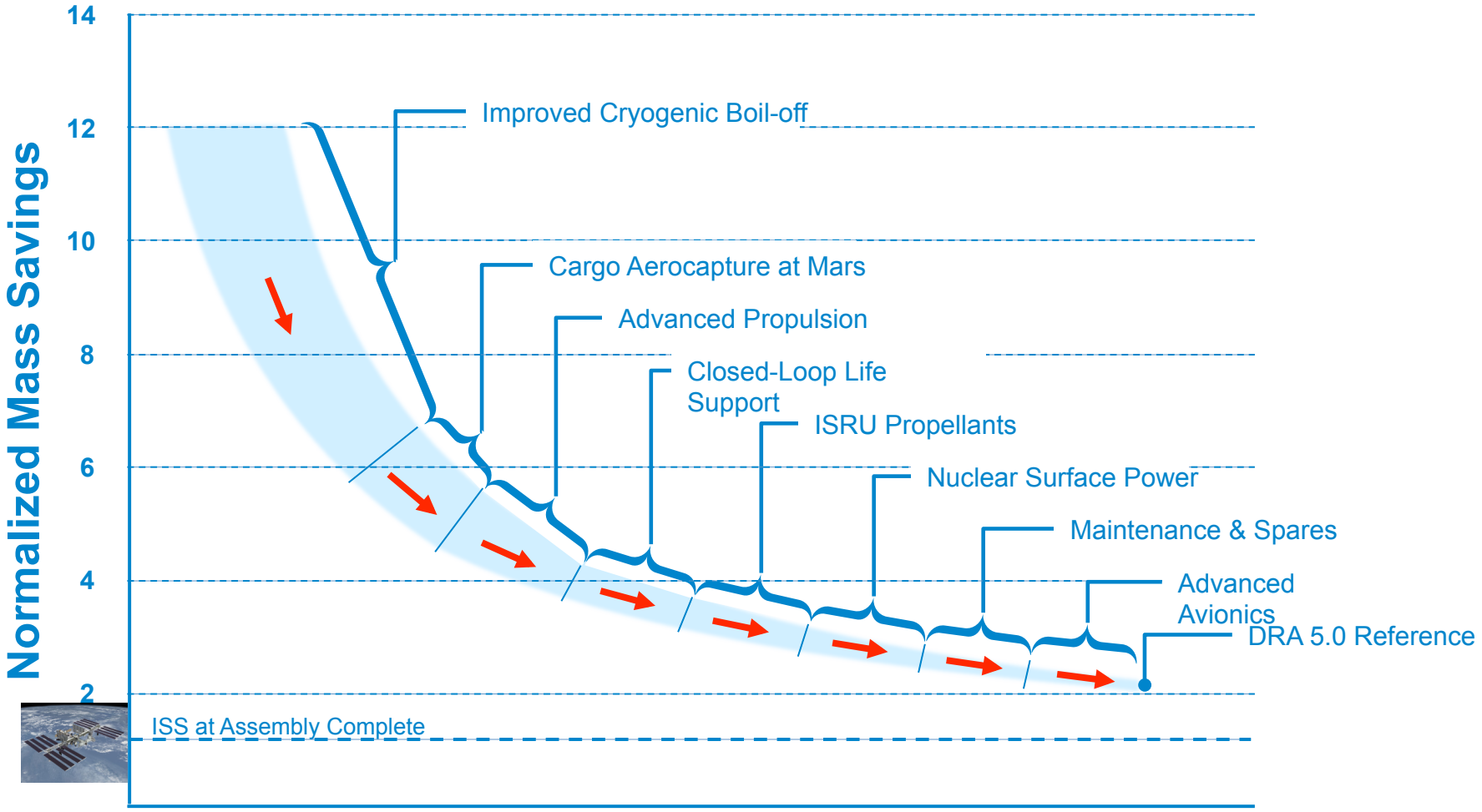
- **NASA Authorization Act of 2008:** "*A robust program of long-term exploration-related research and development will be essential for the success and sustainability of any enduring initiative of human and robotic exploration of the solar system.*"
- **NRC report, A Constrained Space Exploration Technology Program: A Review of NASA's ETDP, 2008:** *"NASA has created a supporting technology program very closely coupled to the near-term needs of the Constellation Program. This program contains only incremental gains in capability and two programmatic gaps. NASA has effectively suspended research in a number of technology areas traditionally within the agency's scope. This could have important consequences for those portions of the VSE beyond the initial short-duration lunar missions, including extended human presence on the Moon, human exploration of Mars, and beyond."*
- **NRC report, America's Future in Space, 2009:** "*NASA should revitalize its advanced technology development program by establishing a DARPA-like organization within NASA as a priority mission area to support preeminent civil, national security (if dual-use), and commercial space programs."*
- **NRC report, Fostering Visions for the Future: A Review of the NASA Institute for Advanced Concepts, 2009:** "*To improve the manner in which advanced concepts are infused into its future systems, the committee recommends that NASA consider reestablishing an aeronautics and space systems technology development enterprise. Its purpose would be to provide maturation opportunities and agency expertise for visionary, far-reaching concepts and technologies."*
- **Augustine Committee, 2009:** "*The Committee strongly believes it is time for NASA to reassume its crucial role of developing new technologies for space. Today, the alternatives available for exploration systems are severely limited because of the lack of a strategic investment in technology development in past decades.*"
- **NRC report, Capabilities for the Future: An Assessment of NASA Laboratories for Basic Research, 2010:** "*To restore the health of the fundamental research laboratories, including their equipment, facilities, and support services, NASA should restore a better funding and leadership balance between long-term fundamental research/technology development and short- term mission-focused applications.*"

NASA's Integrated Technology Programs

- A portfolio of technology investments which will enable new approaches to NASA's current mission set and allow the Agency to pursue entirely new missions of exploration and discovery.



The Value of Technology Investments
Mars Mission Example



- Without technology investments, the mass required to initiate a human Mars mission in LEO is approximately twelve times the mass of the International Space Station
- Technology investments of the type proposed in the FY 2011 budget are required to put such a mission within reach

The New Path for Human Space Exploration

- **The renewed emphasis on technology in the President's FY11 budget request balances the long-standing NASA core competencies of R&T, spaceflight hardware development, and mission operations.**
- **Funding is provided for critical enabling human exploration including:**
  - Technology development and demonstrations to reduce cost and prove required capabilities for future human exploration
  - Research & development of heavy-lift and propulsion engines and other key developments
  - Exploration precursor robotic missions to multiple destinations to cost-effectively scout human exploration targets and identify hazards and resources for future human exploration
  - Increased investment in Human Research utilizing ISS to prepare for long journeys beyond Earth
  - Expanded efforts to develop U.S. commercial human spaceflight capabilities, making space travel more accessible and affordable
- **Technology investment strategy: Needed capabilities are identified, multiple competing approaches to provide that capability are funded, and the most viable of these are demonstrated in flight so that exploration architectures can then reliably depend upon them.**
- **The FY2011 budget will continue the development of the an Orion-derived vehicle that will serve as an emergency return vehicle from ISS, and will be part of the technological foundation for advanced spacecraft to be used in future deep space missions.**

Consistent Set of Exploration Capability Investments

	1969	1986	1987	1988	1989	1990	1991	1997	2004	2009
	Post-Apollo Space Program (NASA STG)	Pioneering the Space Frontier (Paine)	America's Future in Space (Ride)	Beyond Earth's Boundaries (NASA)	90-Day Study (NASA)	Future of U.S Space Program (Augustine)	America at the Threshold, SEI (Stafford)	Human Exploration of Mars DRM (NASA)	President's Commission on U.S. Space Exploration Policy (Aldridge)	Report of U.S. Spaceflight Committee (Augustine)
Advanced/Closed Loop Life Support		X	X	X	X	X	X	X	X	X
Advanced Power Generation & Storage (in-space and surface, Solar and nuclear)	X	X	X	X	X	X	X	X	X	X
Advanced In-Space Propulsion (chemical, solar electric, nuclear thermal, nuclear electric)	X	X	X	X	X	X	X	X	X	X
In-Space Cryo/Propellant Transfer and Storage		X	X	X	X		X	X	X	X
Heavy Lift Launch Vehicle			X	X	X	X	X	X	X	
Autonomous/Expert Systems		X	X			X		X	X	X
Robotics (tele-robotic & autonomous operation)		X	X		X	X	X	X	X	X
EDL (includes aerocapture, aerobraking, aeroentry)		X	X	X	X	X	X	X	X	X
Human Health and Performance (Radiation, gravity, psychological effects and mitigation, medical technologies)	X	X	X		X	X	X	X	X	X
Autonomous Rendezvous and Docking				X	X		X		X	X
In-Situ Resource Utilization (Lunar, NEO, and Mars based)		X	X	X	X	X	X	X	X	X
Lightweight Structures and Materials		X					X	X	X	X
Advanced In-Space Engine					X	X	X		X	X
Advanced EVA Systems		X		X	X	X	X	X	X	
Communication Technology	X				X	X	X		X	
Reliable Efficient Low Cost Advanced Access to Space	X		X							X
Reusable In-Space Transfer	X	X	X		X	X				
Surface Rovers				X			X	X		

Phased Development Strategy

2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026

Phase I
Build the Foundation

Commercial Sector, Robotic Precursors, and Game-Changing Technology Development

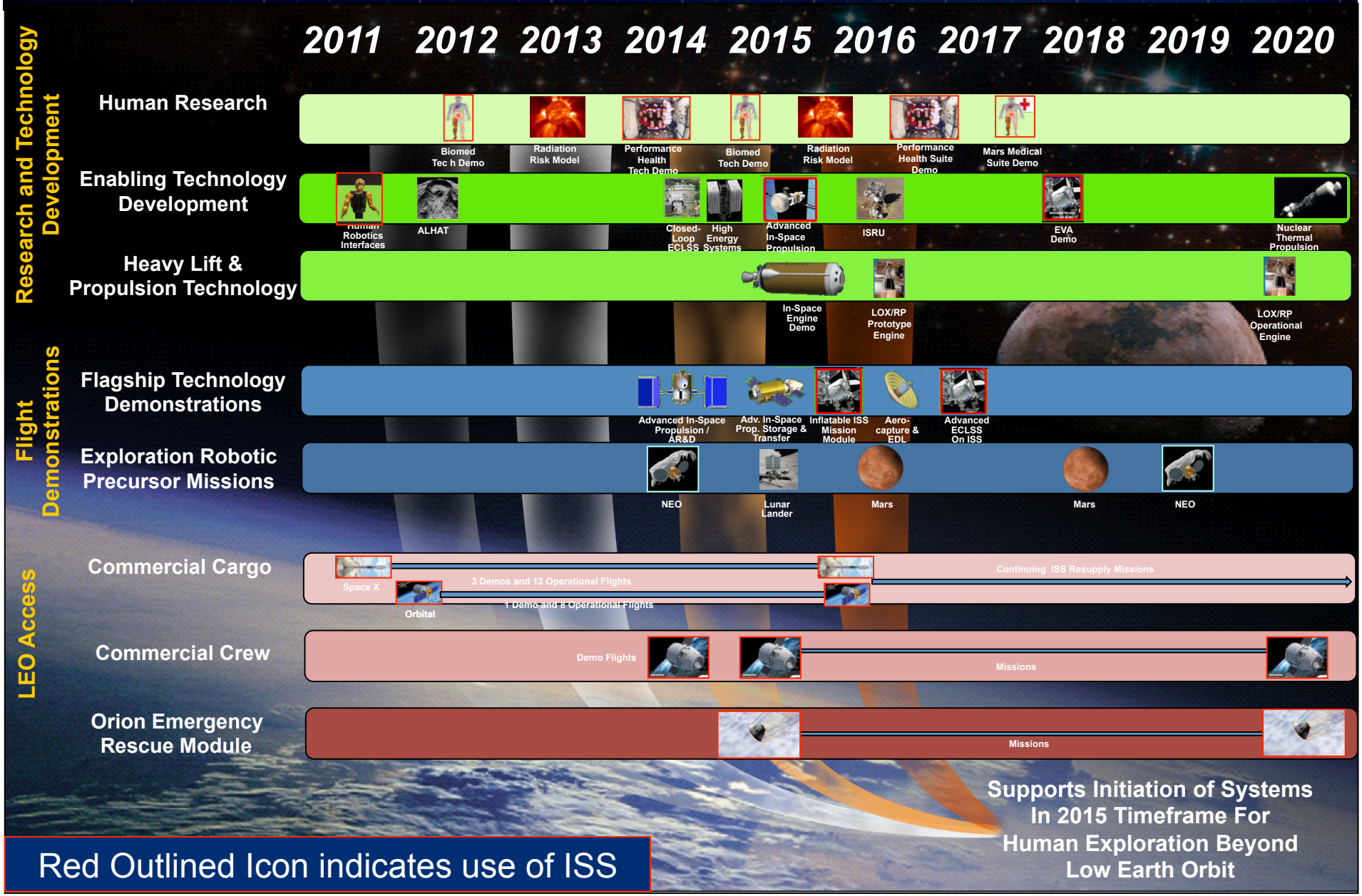
Phase II
Systems Development

Design and Development of Heavy-Lift and In-space capabilities

Phase III
Sustainable Exploration of the Solar System

Human Exploration Missions to Solar System Destinations

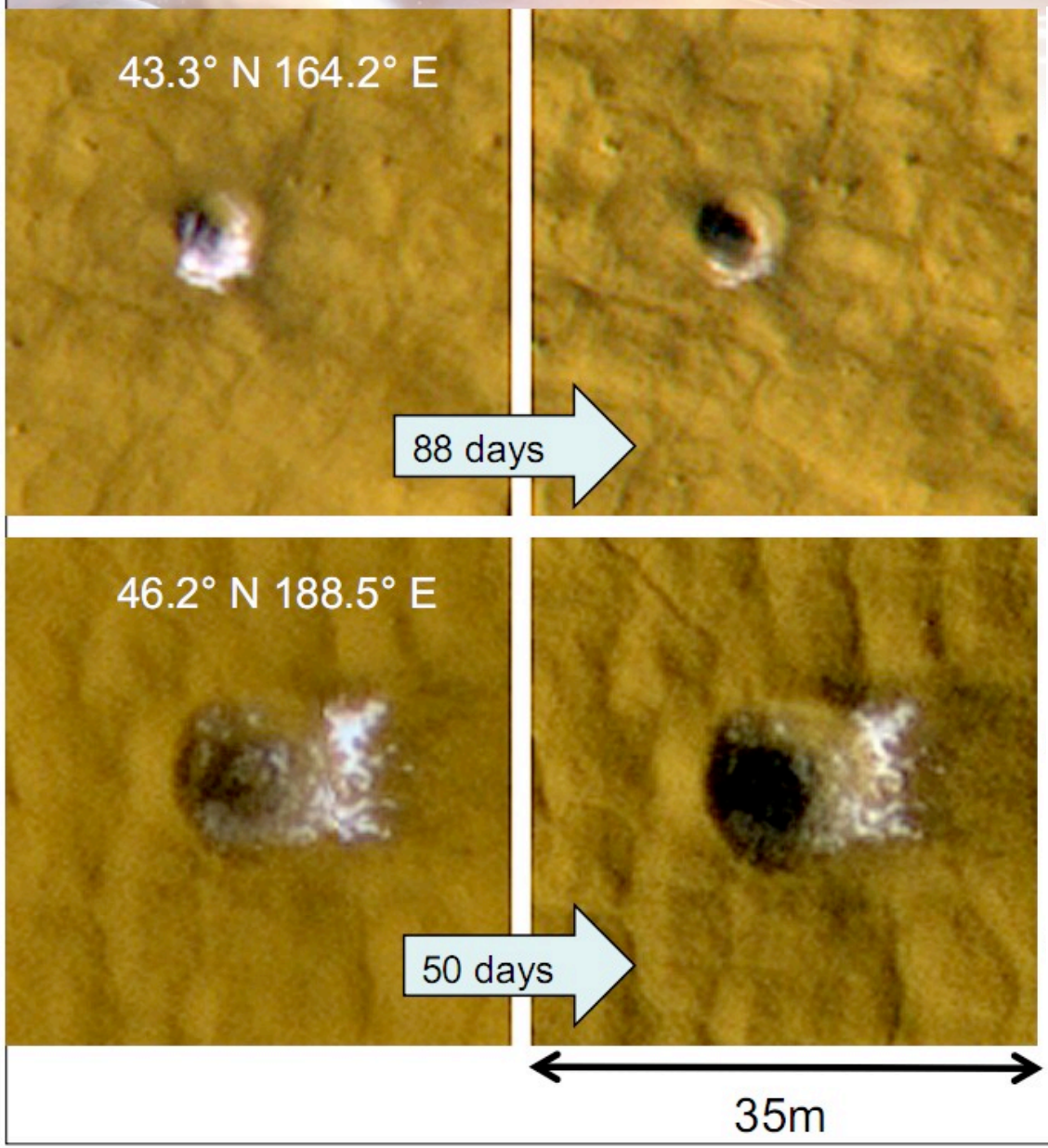
Initial Point of Departure Program Plans



Red Outlined Icon indicates use of ISS

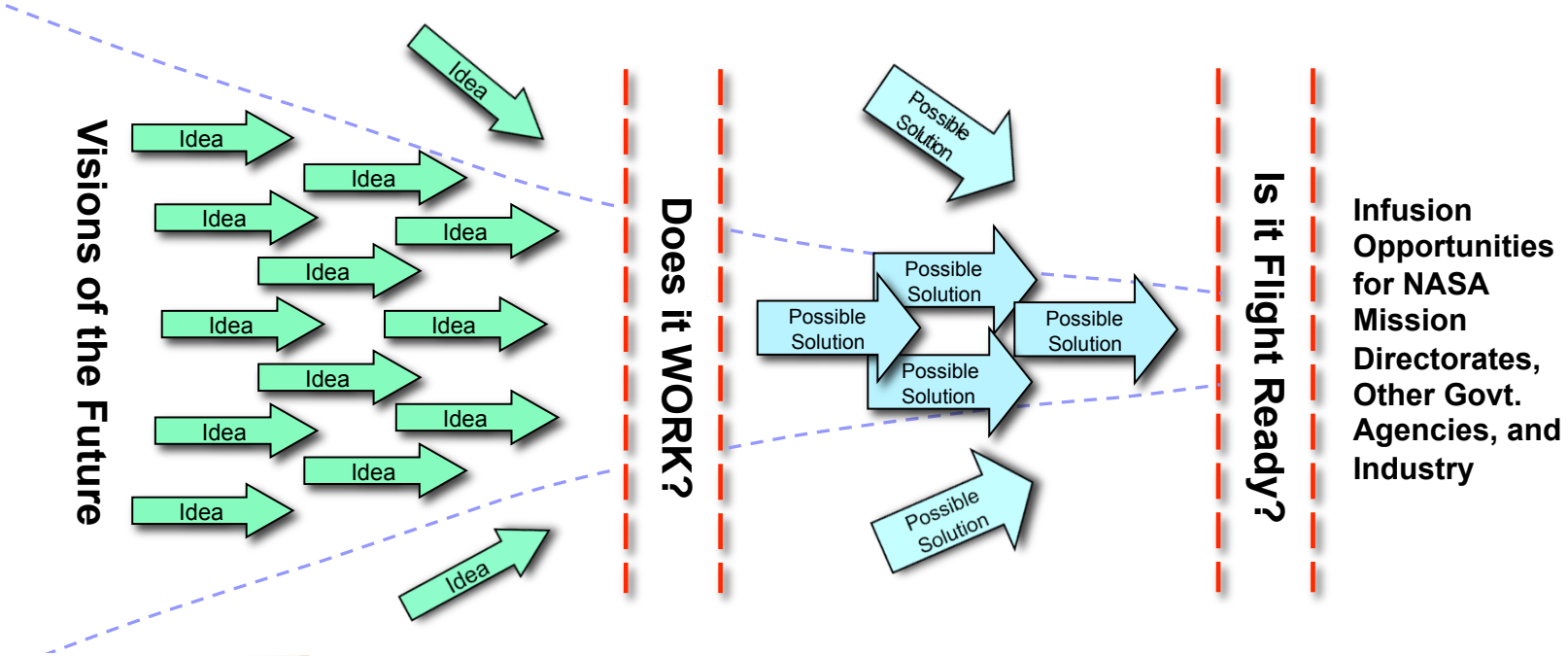
Supports Initiation of Systems In 2015 Timeframe For Human Exploration Beyond Low Earth Orbit

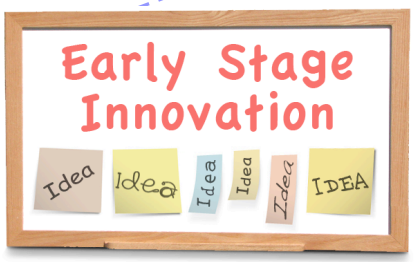
The Value of Robotic Precursor Missions



- Fresh, small impact craters show:
  - Ice layer ~0.5-1 m below surface
  - Sublimates over several weeks
- Spectral analysis shows 99% pure water
- Implication is extensive water ice available at mid-latitudes on Mars
- May change entire resource utilization strategy including which engines are chosen for Mars Return Vehicle

NASA Space Technology Program





Creative ideas regarding future NASA systems or solutions to national needs.

Prove feasibility of novel, early-stage ideas with potential to revolutionize a future NASA mission and/or fulfill national need.

Mature crosscutting capabilities that advance multiple future space missions to flight readiness status

Divisions & Programs

1) **Early-Stage Innovation**: Creative ideas regarding future NASA systems and/or solutions to national needs.
   - NIAC2
   - Space Technology Research Grants (includes Fellowship program)
   - SBIR/STTR
   - Centennial Challenges
   - Center Innovation Fund

2) **Game Changing Technology**: Prove feasibility of novel, early-stage idea that has potential to revolutionize a future NASA mission and/or fulfill national need.
   - Game Changing Development
   - Small Satellite Subsystem Technology

3) **Crosscutting Capability Demonstration:** Maturation to flight readiness of cross-cutting capabilities that advance multiple future space missions, including flight test projects where in-space demonstration is needed before the capability can transition to direct mission application.
   - Technology Demonstrations Missions
   - Edison Small Satellite Demonstration Missions
   - Flight Opportunities

Potential Grand Challenges

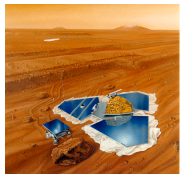
Make space access economical

Provide economical energy on demand

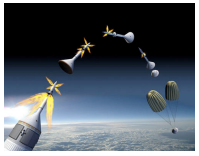
Develop routine satellite servicing

Forecast natural disasters

Manage climate change



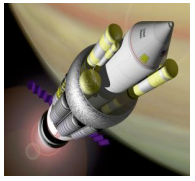
Provide participatory exploration



Improve spacecraft safety and reliability

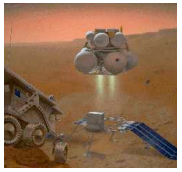
Provide carbon-neutral mobility

Protect astronaut health



Engineer faster space vehicles

Unleash machine intelligence

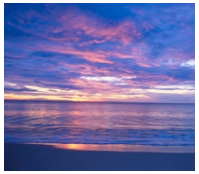


Utilize space resources to explore

Prevent orbital debris

Secure the planet from space threats

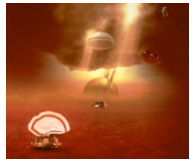
Understand physics governing the universe



Establish conditions for permanent humans in space

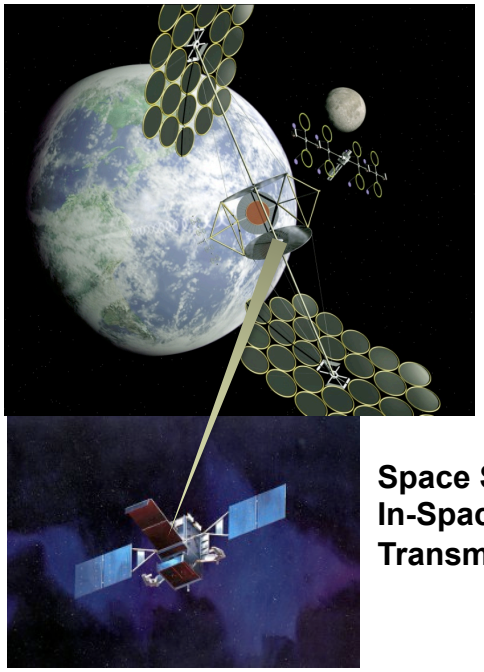
Develop personalized STEM learning

Engineer the tools of scientific discovery

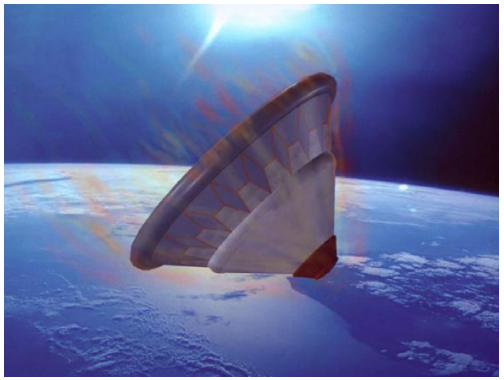


Discover life beyond earth

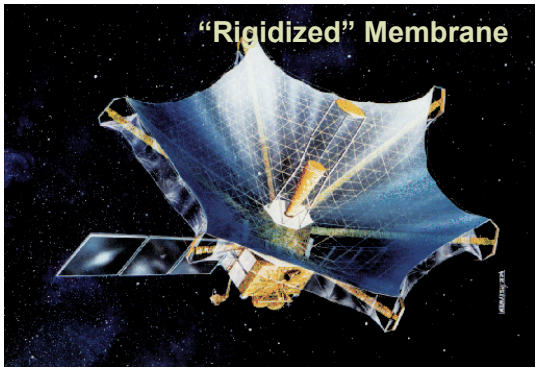
Potential Space Technology Demonstrations



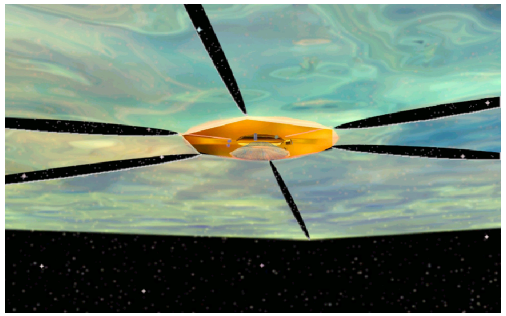
Space Solar Power: In-Space Power Transmission



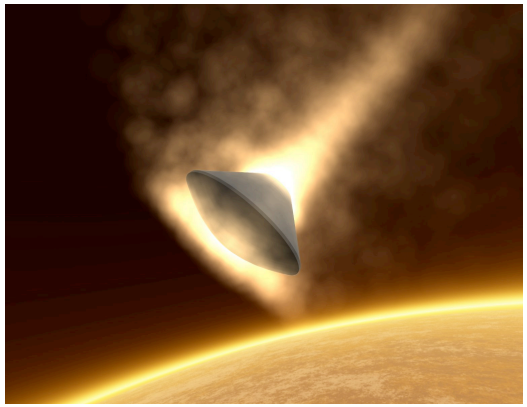
Inflatable Decelerators



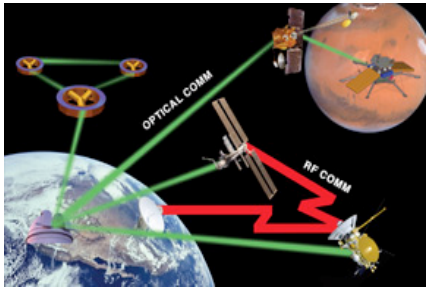
25-40 m Class Telescopes



Solar Sail Propulsion



Aerocapture



Optical Communications

Electrodynamic Tether Propulsion
Artist Concept of ISS Reboost

Role of the NASA Marshall Space Flight Center

Heavy Lift and Propulsion Research and Development Program: New Program Office to manage $559 million in FY 2011 and $3.1 billion over five years to develop next-generation engines and propulsion technologies.

Robotic Exploration Precursor Program: New Program Office to manage the majority of the $125 million in FY 2011 and $3.0 billion over five years allocated to gather critical knowledge of the locations for eventual human visits.

Space Technology Demonstrations: New Program Office to manage $75 million in FY 2011 and $1.4 billion over five years to mature crosscutting aerospace technologies.

Centennial Challenges Program: New Program Office to manage $10 million in FY 2011 and $50 million over five years for this innovative prize program.

NASA: Part of a Broader National Strategy

- Through its FY11 budget request, the Obama administration is committed to a research, technology and innovation agenda for the Nation as a means of stimulating the economy and building our Nation's global economic competitiveness through the creation of new products and services, new business and industries, and high-quality, sustainable jobs
- The NASA budget request is aligned with this National strategy.
  - The renewed emphasis on technology in the President's FY11 budget request balances the long-standing NASA core competencies of R&T, spaceflight hardware development, and mission operations.
- In addition to providing a more more vital and productive aerospace future than our country has today, a NASA focused on technology and innovation,
  - Drives our Nation's economic competitiveness.
  - Serves as a strong inspiration for young people to pursue STEM education and career paths.
  - Allows NASA to apply its intellectual capital to the develop technological solutions addressing broader National needs in energy, weather & climate, Earth science, health & wellness, and National security.

I am 100 percent committed to the mission of NASA and its future. Because broadening our capabilities in space will continue to serve our society in ways we can scarcely imagine. Because exploration will once more inspire wonder in a new generation: sparking passions, launching careers. And because, ultimately, if we fail to press forward in the pursuit of discovery, we are ceding our future. President Obama, April 15, 2010.